

Electrical steering controlled by ECU for automobiles based on mechatronics approach

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ABSTRACT

In this paper vehicle steering concepts based on Steer-by-wire systems are examined. Advantages taken from the use of such systems are outlined; the control architecture and objectives in connection with the needed sensors are detailed. Vehicle steering systems may be classified according to the presence or not of a mechanical connection between the driver hand wheel and the tire steering mechanism. Steering systems with this linkage are called conventional and the ones without, are called steer-by-wire. Conventional steering mechanism undergoes several developments from the manual steering to Hydraulic Power Steering (HPS). The main objective consisted in decreasing the driver steering effort. These systems which we call Electronic Power Steering (EPS), are easy electronic implementation of variable steering assistance such as parking assistance or velocity depend assistance. The paper proposes a new steering mechanism for use in automobiles based on mechatronics approach. The steering geometry used in conventional vehicles is Ackerman or Davis, which suffer from their own drawbacks. The idea is to actuate the steering using linear electric actuator controlled by an Electronic Control Unit.

Keywords: Electrical Steering; Automobiles; Mechatronics ; ECU

1.0. INTRODUCTION

The idea is to control the steering in such a manner that the Law of Steering is followed at all points in the trajectory of motion of the vehicle. At the same time it is completely customizable. Factors like over steer and under steer can be adjusted by the driver at any point of time. This steering results in pure rolling about the instantaneous center of rotation with zero skid. For correct steering the wheels would be in planes which are tangential to the respective paths in order that the relative motion between ground and the wheels is pure rolling.

A large number vehicle accidents result from unexpected excessive yaw motion such as spin-out. Vehicle yaw motion is a result of the combination of different phenomena. At first of all, the driver assigns the desired yaw rate through the steering wheel angle and vehicle dynamics. Active safety technologies for vehicles have been mainly developed for power train control. The controller output may consist in an additional steering command which is continuously monitored and added to the driver steering command. Active steering is achieved using only on-board internal vehicle sensors, it may prevent spinning and improve the yaw dynamics. Several works have been conducted in order to specify the role of the controller and the sharing driving with human driver. The controller may not be conflicting with the driver's control, its actions should thus reject only disturbance beyond driver's control.

All these problems arise from the limited possibilities to add the controller output while the driver steering wheel is still mechanically connected to the front steered wheels. Some mechanical steering mechanisms have been proposed but they are generally very expensive, so real progress are expected from the use of systems in which the driver hand wheel is not mechanically connected to the tire steering mechanism. This device adds the needed supplementary degree of freedom as the driver steering angle can be different from the one effectively applied to the tires by a controller. In addition to this, the controller should be robust to several and large parameters variations such as the speed, road adhesion and payload value and distribution. The steering system of an automobile serves two main functions: firstly it allows the driver to make the vehicle follow a desired path or trajectory without requiring excessive physical effort and secondly, it assists the driver to judge the driving conditions by allowing some feedback. The latter is a subtle aspect of the steering system, with the driver in the feedback loop striving to minimize the error which the vehicle may have from the desired path.

2.0. SENSORS

The displacement sensor used is LVDT (Linear variable differential transducer). Slide potentiometer sensors are mostly preferred in today's automotive applications for measuring angles, owing to the know-how gained from decades, its simple construction and low prices. The main drawbacks are contact problems with respect to wear and soiling and accuracy restrictions at given low contact current levels. Increasing competition is now coming from principles based on modern microelectronics that use special non-contacting physical and technical effects to avoid the disadvantages of potentiometers. The common principles are: magnetic measuring methods based on

- (a) The Hall Effect
- (b) Variations in the magnetic resistance of permalloy (81% Ni–19% Fe), the so-called magneto resistive (MR) effect;
- Capacitive methods based on varying coupling ratios among several electrodes;

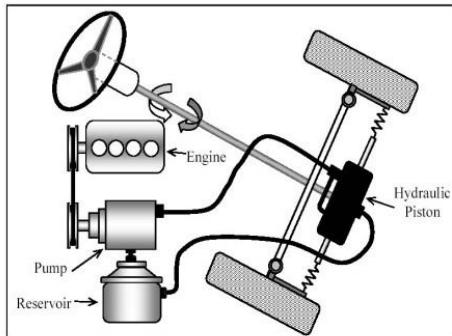


Figure 1(a)

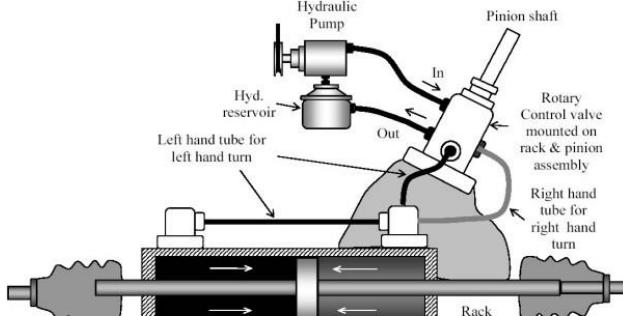


Figure 1(b)

Figure 1

Functional schematics of a power assisted steering systems

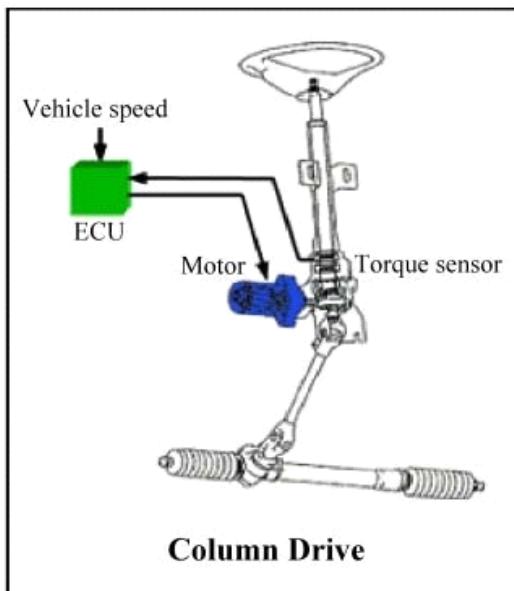


Figure 3

Illustration of an EPAS

Nearly 50 years since the first introduction of hydraulic power assisted steering, another technological leap is taking place in the area power assisted steering. This involves replacing the hydraulic system with an all electric system in which power is delivered to the rack and pinion of the steering mechanism only when required (i.e., on demand). In this electric power assisted steering (EPAS), an electric motor drives the rack and pinion arrangement to steer the vehicle using power from the battery, as illustrated in Figure 3.

Little power is used or wasted when the vehicle is running at a reasonable speed or when steering is not required. The constant parasitic loss of the HPAS is thus eliminated. The battery supplies all the steering power needed for cornering or parking at low speed. The operation of the EPAS is achieved by firstly sensing the amount of effort, or torque, applied to the steering wheel by means of a torque sensor. This torque sensor is easily incorporated within the steering column. An electric circuit is able to relay this information into an electronic control unit (ECU). The control algorithm generates a signal that drives the electric motor to provide steering assistance. The power to the motor is from the vehicle battery, and it is controlled electronically without incurring much loss.

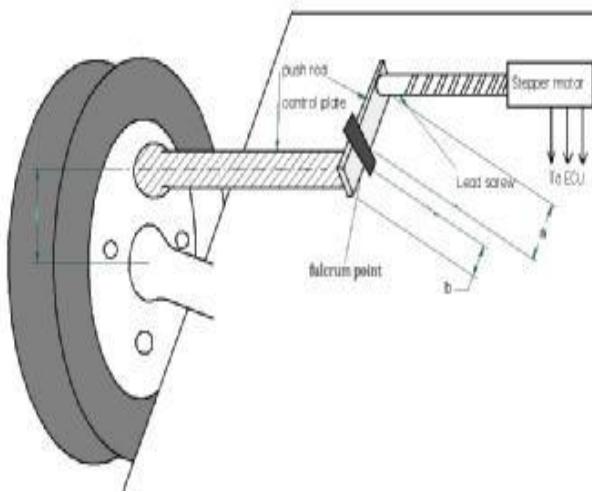


Figure 2

- Optical sensors; and
- Inductive principles

The normally complex mechanical structure and the precision coils required have so far made it difficult to apply inductive sensors in automobiles. Newly developed innovative sensors overcome these problems and are especially suited for low-cost mass production. It consists of a stator containing an excitation coil, receiver coils and signal-processing electronics, plus a rotor comprising one or more closed conductor loops with a given geometry. Alternating current is sent through the transmitter coil, generating an alternating magnetic field. This magnetic field permeates the receiver coils and conductor loops of the rotor. Voltages are induced in the receiver coils that can then be read out by an electronic signal-processing unit. The

alternating magnetic field in the rotor conductor loop induces a current that influences the excitation field. The influence of the magnetic fields follows the special geometry of the conductor loop instead of being uniformly distributed over the sensor circumference. This renders the voltage amplitudes in the receiver coils dependent on the position of the rotor in relation to the stator. The electronic signal processor rectifies the alternating voltages of the receiver coils, amplifies them and puts the output voltages of pairs of receiver coils into a ratio metric relationship. This ratio metric measurement method produces an output signal proportional to the angle, which is to a great extent independent of mechanical tolerances such as clearance, backlash, etc. Furthermore the sensor system is insensitive to electrical and electromagnetic disturbances because of the radiometric principle. Sensor temperature stability can easily be achieved, because, unlike the magnetostatic principles, there are no materials with a temperature-dependent magnetic permeability such as iron cores, ferrites or magnetic cores. Any temperature drifts resulting from geometrical changes or electronic signal processing are also eliminated by the ratio metric principle.

3.0. WORKING

The rotational movement at the steering wheel is sensed by the rotational sensor which sends the signal to the ECU. The ECU then calculates the correct angle of rotation for the inner and outer wheels based upon the steering equations. It also calculates various other parameters like the force required on the actuator and length of extension of the linear actuator. The signal in pulsed form is then sent to the actuator. The extension of the actuator is sensed by the position sensor, which guides the ECU to stop any further movement of the actuator after the correct movement is attained. The steering ratio is also accounted for by the ECU for more control over the amount of steer. The steering wheel is made such that when the wheel is released after rotation, it retracts back to the central position for the vehicle. This results in simulation of self-centering action of conventional steering. In case of failure of engine or other systems the power will still be available for maneuver.

Column-assist type (CC-EPAS) systems were the early systems introduced by Koyo in 1988 for larger automobiles. In this system, a brushed DC motor was integrated in the steering column. The motor was located in the passenger compartment. The recent trend for light and subcompact vehicles is toward pinion-assist (P-EPAS) which has higher motor output and can be located in the engine compartment.

4.0. CONCLUSION

The design of a new steering geometry that is powered by the electronics is more accurate but the application of the same to the real vehicle requires more testing. The electronic simulation of the model was successfully tested. It is ensured that the system prevents skidding during both low speed as well as high speed turning. And from the above, we can conclude that the steering torque is dependent on the speed, acceleration and the load acting on the vehicle. These following factors can be controlled by the ECU by giving the respective signal input and data.

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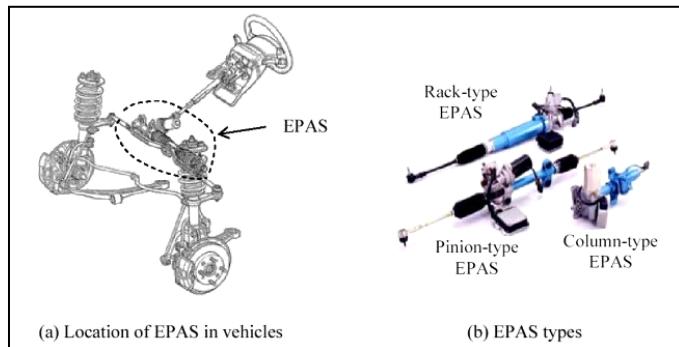


Figure 4